Spatially Resolved Neutron–Gamma Discrimination Using Neutron-Sensitive Scintillators and Event-Mode Imaging

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Portable radiographic systems typically rely on either x-ray/gamma imaging or neutron imaging, requiring separate sources and detector systems to obtain complementary information. This limits deployment in field environments where system complexity, size, and measurement time are constrained. A single, portable imaging system capable of producing co-registered neutron and photon radiographs from one source and one detector remains an open challenge.

In this work, we investigate event-mode imaging systems coupled with neutron-sensitive scintillators as a pathway toward bi-modal neutron and gamma radiography using a single-source, single-camera setups. Event-mode cameras based on Timepix-3 sensors have previously demonstrated the ability to reconstruct individual particle interactions from scintillation light with high spatial and temporal resolution, enabling advanced neutron imaging and energy-resolved neutron radiography [1–3]. Rather than integrating scintillation light over long exposure times, these systems record individual optical photons on a pixelated sensor, providing access to the internal structure of each scintillation event.

Here, we focus on exploiting this capability for spatially resolved particle discrimination. Neutron-sensitive scintillators with well-established pulse-shape discrimination characteristics are optically coupled to Timepix3-based event-mode cameras, such as LumaCam systems [1,2]. Measurements are performed using low-activity gamma and neutron sources to isolate the photon emission associated with individual interaction types. By analyzing the spatial and temporal distributions of scintillation photon clusters, differences in light-emission behavior between neutron and gamma interactions can be identified at the event level while preserving spatial information.

These measurements are used to build an empirical understanding of system response, assess the robustness of particle identification strategies in mixed radiation fields, and inform the development of simultaneous neutron and gamma image reconstruction from a single detector. The results demonstrate how event-mode imaging, when combined with neutron-sensitive scintillators, provides a practical route toward compact, bi-modal radiographic systems and highlights the critical role of scintillator light-emission characteristics in spatially resolved particle discrimination.

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